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E. J. STONE, M.A., F.R.S., President, in the Chair.

Prof. S. P. Langley, Allegheny Observatory, Pennsylvania;
Prof. J. A. C. Oudemans, the Observatory, Utrecht;
Prof. P. Tacchini, Collegio Romano, Rome; and
Prof. E. Weiss, the Observatory, Vienna;
were balloted for and duly elected Associates of the Society.

James S. Cooke, Springfield, Gomersal, near Leeds;
Alexander von Gothard, Herény Observatory, Hungary;
Eugen von Gothard, Herény Observatory, Hungary;
Capt. Richard Ladd, F.M.S., 106, Sandgate Road, Folkestone; and
Robert Rawson, Assoc. I.N.A., Havant, Hants;

were balloted for and duly elected Fellows of the Society.

Note on the Greenwich Mean Tabular Errors of the R. A. of the Sun. By E. Dunkin, F.R.S.

In the table of mean tabular errors of the Sun in longitude given by Mr. Stone in his paper on "An Explanation of the Principal Cause of the larger Errors at present existing between the Positions of the Moon deduced from Hansen's Tables and from Observation," &c. (*Monthly Notices*, vol. xliii. p. 337), the changes appear so remarkable, especially in the almost sudden increase in the errors after the year 1872, that it is highly important that any explanation of this apparent increase in the tabular errors of longitude, or of the R.A. of the Sun, should be at once placed on

record. Mr. Stone considers that the general increase is clearly progressive, amounting roughly to 0″·052 per annum, and he believes that it is the effect of the change of unit adopted by Le Verrier in his Solar Tables.

Without wishing to enter into a controversy on the subject of Mr. Stone's paper, I think I may venture to offer another explanation, which will also clearly show that this apparent positive increase in the observed tabular errors of the R.A. of the Sun may be accounted for as being the effect of "personality" in the observers employed in making the observations. It so happened that between the years 1872 and 1875 several important changes took place in the regular observing staff at Greenwich. Observers who were in the habit of systematically giving large negative errors were succeeded by others who, on the contrary, give large positive errors. The existence of a peculiar personality in observing the limbs of the Sun and Moon has been known to me for many years, long before the preparation of my two papers on personality in observing transits of the first and second limbs. In these papers I have conclusively shown that even experienced observers differ widely in their methods of observing the limbs of the Sun and Moon (*Monthly Notices*, vols. xxix. and xxxv.)

The numbers given in the following table for each of the principal observers show how much the mean tabular errors of the R.A. of the Sun have been affected by the introduction of new observers. These numbers require no explanation further than to state that all the tabular errors in R.A. of the Sun have been extracted, without exception, from the "Astronomical Results" contained in the *Greenwich Observations* for the years from 1864 to 1881. These errors have been classified for each year into observers' groups. All the errors deduced from the observations of the computers and other occasional observers are included in one miscellaneous group, but any evidence obtained from this group is of lesser importance, as the observers are never in any two years the same, and many of them have not attained the trained experience of the assistants. In the following table the yearly mean errors derived from the observations of all the occasional observers are inserted, but no attempt has been made to ascertain the amount of their separate personalities, though the errors themselves show that personality exists in some instances in a tolerably large degree.

In the following tables the initials of the observers D, E, L, C, JC, AD, T and TL, are respectively those of Mr. Dunkin, Mr. Ellis, Mr. Lynn, Mr. Criswick, Mr. Carpenter, Mr. Downing, Mr. Thackeray, and Mr. Lewis. The mean tabular errors are expressed in seconds of arc.

Mean Tabular Errors of R.A. of the Sun.

Year.	D Tab. Error of R.A.	No. of Obs.	E Tab. Error of R.A.	No. of Obs.	C Tab. Error of R.A.	No. of Obs.	JC Tab. Error of R.A.	No. of Obs.	Miscellaneous. Tab. Error of R.A.	No. of Obs.
	"		"		"		"		"	
1864	−0·07	17	−0·25	23	+0·19	28	−0·97	24	+1·03	30
1865	−0·09	21	+0·18	24	+0·55	28	−0·03	19	+0·38	29
1866	−0·34	19	−0·87	20	−0·10	16	−0·67	21	+0·67	33
1867	−0·36	14	−1·48	16	+0·84	17	−0·79	18	+0·26	27
1868	+0·13	21	−0·88	21	+0·21	25	−0·19	19	+0·84	45
1869	+0·55	14	−0·58	18	+0·51	18	−0·17	18	+0·82	30
	L									
1870	+0·21	18	−0·46	20	+0·45	23	−0·56	28	+0·75	37
1871	−0·03	28	−0·17	15	+0·18	16	−1·17	15	+1·42	39
1872	+0·79	25	−0·91	23	−0·07	19	−1·29	16	+0·39	37
							AD			
1873	+0·91	21	−0·60	20	+0·33	20	+0·61	29	+0·90	34
1874	+1·09	22	−0·34	12	+0·52	20	+1·72	20	+0·62	32
			T							
1875	+1·08	17	+0·15	15	+0·45	15	+0·84	15	+0·97	49
1876	+1·33	12	+0·20	22	+0·36	16	+0·64	24	+1·08	38
1877	+0·24	9	+0·08	13	+0·79	13	+0·42	16	+1·06	34
1878			+0·78	12	+0·33	14	+0·21	14	+1·05	45
1879			+0·66	13	+0·08	15	+0·31	15	+1·29	34
1880			+0·69	20	+0·19	17	−0·09	27	+1·53	51
	TL									
1881	+1·14	27	+0·52	19	+0·22	17	+0·48	24	+0·96	33

From 1878 to the end of 1880, owing to the illness and subsequent resignation of Mr. Lynn, three assistants only made regular observations with the Transit Circle, which accounts for the rather larger number of observations made by the computers in those years.

Referring all the numbers in the preceding table to Mr. Criswick as the standard, and dividing the group of each observer into smaller groups determined either by the change of observers or when there is shown a decided difference in the value of the errors, we obtain a series of comparisons between Mr. Criswick and each observer, and indirectly between any two observers; and thus corrections can be deduced to be applied to the mean of all the errors for the years between which a change of observers took place.

Period.	Observers.	Difference.	
		"	
1864–1869	D−C =	−0·40	
1864–1869	E−C =	−1·01	Mean = −0″·90
1870–1874	E−C =	−0·78	
1864–1869	JC−C =	−0·84	Mean = −1″·02
1870–1872	JC−C =	−1·19	

Period.	Observers.	Difference.
1870–1871	L–C =	−0 23
1872–1877	L–C =	+0·51
1873–1874	AD–C =	+0·74
1875–1881	AD–C =	−0 01
1875–1881	T–C =	+0·09
1881	TL–C =	+0 92

Assuming on an average that the number of observations of each observer is approximately about one-sixth part of the whole number for each year, corrections have been determined from these differences, and applied to form the corrected values in the third and sixth columns in the next table. It will be observed that though the discordances in the third column of mean errors are greatly diminished between the periods before and after 1873, the errors are not entirely cleared of the personality, as it still remains in full force in the miscellaneous group, which has in some years a very considerable weight in determining the yearly combined mean of the tabular errors. The following table contains the mean of the errors determined by all the observers for each year, with the resulting values as corrected for the personality due to the changes in the assistants, and also the means of the tabular errors determined from observations made by the assistants only, with the corresponding resulting values corrected for personality.

Year.	Uncorrected Mean Tab. Error of R.A. of Sun from all the Observations.	Mean Tab. Error of R.A. of Sun corrected for Personality due to change of Assistants.	No. of Obs.	Uncorrected Mean Tab. Error of Sun from Observations by the Assistants only.	Mean Tab. Error of Sun from Observations by the Assistants only, corrected for Personality due to change of Assistants.	No. of Obs.
	″	″		″	″	
1864	+0·05	+0·05	122	−0·27	−0·27	92
1865	+0 23	+0·23	121	+0·20	+0·20	92
1866	−0·17	−0·17	109	−0·53	−0·53	76
1867	−0·20	−0·20	92	−0·44	−0·44	65
1868	+0·24	+0·24	131	−0·17	−0·17	86
1869	+0·15	+0·15	98	+0·07	+0·07	68
1870	+0·13	+0·09	126	−0·12	−0·16	89
1871	+0·32	+0·28	112	−0·22	−0·26	74
1872	−0·12	−0·30	120	−0·27	−0·54	83
1873	+0·51	+0·04	124	+0·36	−0·35	90
1874	+0·80	+0·33	106	+0·57	−0·14	74
1875	+0·79	+0·30	111	+0 65	−0·11	62
1876	+0·75	+0·26	112	+0·56	−0·20	74
1877	+0·66	+0·17	85	+0·40	−0·36	51
1878	+0·75	+0·42	85	+0·42	−0·24	40
1879	+0·75	+0·42	77	+0·34	−0·32	43
1880	+0·81	+0·48	115	+0·23	−0·43	64
1881	+0·73	+0·18	120	+0·64	−0·18	87

The effect of the change of assistants on the tabular error of the R.A. of the Sun as determined from observations made with the Transit Circle is well marked in the preceding table, especially in the fifth and sixth columns, in which the errors determined from the observations of the computers have been omitted. It may be remarked that in 1870 Mr. Dunkin was succeeded by Mr. Lynn; in 1873 Mr. Carpenter by Mr. Downing; in 1875 Mr. Ellis by Mr. Thackeray; and in 1881 Mr. Lynn by Mr. Lewis.

Some of the outstanding discordances in the third column can be explained by an examination of the separate errors as given by each observer. In 1866 and 1867 two computers had undoubtedly a considerable negative personality, while as a rule it has been noticed that the young observers have a tendency to observe either the first or second limb too early, and consequently the tabular errors in R.A. for the centre of the Sun are too great. In these years the negative tabular errors determined from the observation of some of the assistants are also larger than in other years. From 1878 to 1880, owing to Mr. Lynn ceasing to observe, it became necessary to employ computers more than usual to supply his place; and the effect of their exceptionally large errors, due to personality principally, is shown in the corrected mean errors for those three years, in which a large personality for the miscellaneous group remains. In 1872 there was a great preponderance of negative errors, the cause of which cannot at present be explained.

The only assistant who has observed continuously from 1864 to 1881 is Mr. Criswick, and as it is found from the comparison of his observations with those of the other observers that no sensible change has taken place in his method of observing the Sun during the whole period, the errors deduced from his observations ought to give some reliable evidence of a progressive increase in the tabular error of R.A., if such a change be really in progress. Dividing his observations into three groups, and also the corresponding corrected errors determined by the assistants, we have:

Period.	Mean Tab. Error of R.A.	No. of Obs.	Mean corrected Tab. Error of R.A. by Assistants.	No. of Obs.
	″		″	
1864–1869	+0·36	132	−0·19	479
1870–1875	+0·32	113	−0·26	472
1876–1881	+0·31	92	−0·29	359

These numbers are closer than might have been expected, and they indicate a diminishing rather than an increasing error.

I have already remarked that similar personalities in observing the limbs of the Moon have been shown to exist, and on referring to a comparison of the observations of different observers given in my paper (*Monthly Notices*, vol. xxxv. p. 94), it may be observed that the relative differences are about the same amount as those exhibited above for the Sun.

Royal Observatory, Greenwich,
1883, *November* 8.

Note on the Mass of Saturn. By Prof. Asaph Hall.

(*Communicated by Rear-Admiral R. W. Shufeldt, Supt. of Naval Observatory.*)

At the beginning of my observations with the 26-inch Equatorial at Washington in 1875, the apparent difference of declination of *Iapetus*, the outer satellite of *Saturn*, and the planet was very small. It occurred to me that it would be well to observe the difference of Right Ascension and Declination of the planet and satellite, since the mean distance of the satellite would be determined chiefly from the difference of Right Ascension, and so would not depend essentially on the assumed value of a revolution of the micrometer screw. *Iapetus* was observed therefore in this manner in 1875, 1876, and 1877. The differences of Right Ascension were observed as carefully as possible on a chronograph. In 1875 each difference of Right Ascension depends on about twenty-five transits, and in the other years on about twenty transits. The average probable error of a single difference of Right Ascension is $\pm 0^s.044$. Both limbs of *Saturn* were observed; and in every year the satellite was observed in both positions, preceding and following the planet. Each difference of Declination depends on five bisections of the planet and satellite.

The observed differences of Right Ascension and Declination correspond to what Bessel denotes as x and y in his work on the orbit of *Titan* (*Astronomische Nachrichten*, Band 9); and the equations of condition are formed very conveniently by means of Bessel's formulæ. The equations for each year have been treated separately, since the periodical perturbations of this satellite produced by the Sun are quite large. The solution of the equations of condition by the method of least squares gives the following values of the mean distance of *Iapetus* from *Saturn* at the distance 9·53885.

1875	$a = 515''.594 \pm 0''.056$	57	observations.
1876	$a = 515.454 \pm 0.058$	40	,,
1877	$a = 515.517 \pm 0.053$	31	,,
Mean	$a = 515.522$	128	,,

The following table shows the number of equations of condition for each year; the sum of the squares of the independent terms before solution, the sum of the squares of the residuals after solution, first by elimination, and again by substitution; the maximum residual left in the equations after substitution, and the probable error of a single equation.

Year.	No of Equat.	$[nn]$	$[nn.6]$	$\Sigma.v^2$	Max. Residual	r_1
		$''$	$''$	$''$	$''$	$''$
1875	109	172·274	27·136	27·095	1·49	±0·346
1876	78	107·453	15·806	15·803	1·31	±0·316
1877	61	110·935	8·336	8·324	1·26	±0·263

The values of the mean distance for the different years agree so nearly that it is doubtful, I think, if the same observer can get a better determination of this quantity by this method. Should this mean value prove to be erroneous, then the error must exist in the method employed or in the observer, since the accidental errors seem to be nearly eliminated. The known variability in the brightness of this satellite when on different sides of the planet does not appear to have had any sensible influence on the result.

I have also a series of angles of position and distances observed with the filar micrometer, but the equations for these have not yet been formed.

In order to determine the periodic time of *Iapetus*, I have examined the old observations of this satellite, most of which, however, are of a very unsatisfactory character. A long series of observations made at Marseilles in 1787 by Bernard promised a good determination of the orbit at that date, and such a determination would be valuable, since in this way we could find from the observations the secular variation of the node and the periodic time of the satellite; but after a good deal of labour and many trials I have not been able to understand these observations. Lalande's interpretation of them is probably wrong, since he gets the inclination of the orbit largely in error (*Mém. de l'Académie*, Paris 1786). For the periodic time, therefore, I have used an observation by Sir William Herschel, Sept. 20, 1789, and the observations made by Sir John Herschel at the Cape of Good Hope in 1837. These have been compared with my own observed times of the conjunctions in 1880 and 1881. The adopted value of the sidereal revolution is

$$\text{Periodic Time} = 79{\cdot}3310152 \text{ days.}$$

Combining the above mean distance with this period we have data for determining the mass of *Saturn*. For *Saturn* I find

$$\rho - \tfrac{1}{2}\phi = 0{\cdot}01818,$$

and in the case of *Iapetus*, which is so distant from its primary, I have assumed that the factor

$$1 + \frac{\beta^2}{\alpha^2}(\rho - \tfrac{1}{2}\phi)$$

is unity, this factor being the constant part of the expression, *Méc. Cél.* tome ii. p. 103. The masses of the satellites are unknown, and I have neglected the action of the Ring, since Bessel's value of its mass does not appear to be beyond question. We have therefore for the mass of the planet in units of the Sun's mass—

$$\text{Mass of Saturn} = \frac{1}{3482{\cdot}2}.$$

There is a series of observations of this satellite by Bessel in the volumes of the *Königsberg Observations*, 1832 to 1837. *Iapetus* was compared with *Titan* by means of the Heliometer; and it would be interesting to have a determination of the orbit of *Iapetus*, and of the mass of the planet, from these measures after the method proposed by O. Struve.

Naval Observatory, Washington:
1883, *Sept.* 25.

The Disappearance of the Satellites of Jupiter.

By Wentworth Erck.

The simultaneous disappearance, predicted by the *Nautical Almanac* for the morning of the 15th, did not take place, owing to an error of twenty-four minutes in the *Nautical Almanac* time of egress of the fourth satellite, which passed off the disk just as the third satellite entered on the disk.

The following is an abstract of the notes made on the occasion with a $7\frac{1}{2}$ in. Equatorial, and powers of 100 and 250.

G.M.T. 1883, *Oct.* 14.

12	42	±	I. disappeared, being eclipsed.
13	5	0	Shadows of II. and III. conspicuous; but cannot see Sat. IV., which is on the disk.
	51	15	II. about to enter on the disk.
14	14	12	III. shadow off the disk.
	21	10	II. on the very point of entering; its disk is well defined, as is that of III., but the disk of II. is apparently not more than one-third of the diameter of that of III.
	28	10	II. has now completely entered. Though II. and IV. are on the disk, and the definition good, yet I cannot see the satellites themselves with powers of 100 and 250.
15	36	0	II. shadow off disk.
	50	55	III. first contact with limb.
	50	55	IV. off the disk, at the same moment that III. makes contact at the opposite side of the disk; III. enters on the great Southern Belt, whereas IV. emerges at a point very far S. of the Belt at latitude, perhaps, 30°.
	56	0	III. half on; IV. well off.
	59	25	III. completely on, took about 8^m to enter.
16	13	50	I. re-appearing from occultation.
	15	50	I. completely off. III. not seen on disk.
	20	0	Observations discontinued.

Comparison of Observed Times with Greenwich Times.

		Observed.	Greenwich.	Diff.
1	III. Shadow E.	14 14 12	14 15 0	—
2	II. Tr. Ingress	28 10	33 0	5
3	II. Shadow E.	15 36 0	14 50 0	46
4	IV. Transit E.	51 0	15 15 0	24
5	III. Transit I.	59 25	15 56 0	3
6	I. R. Oc.	16 15 50	16 15 0	—

In the case of No. 3—*i.e.* the egress of the shadow of II.—I cannot at all account for the difference of 46 minutes.

Shankill, Co. Dublin:
1883, *Oct.* 24.

Jupiter without visible Satellites. By the Rev. S. J. Johnson.

The disappearance of *Jupiter's* satellites on the morning of October 15 afforded an interesting instance of the tabular errors of the fourth satellite. Instead of lasting nineteen minutes, as according to the *Nautical Almanac*, it only lasted half a minute, and possibly, with a large instrument, the satellites may never have entirely gone out of sight.

On turning the telescope on *Jupiter* at $3^h\ 45^m$ A.M. I never noticed the belts sharper defined. One satellite, the third, alone remained visible just at the edge of the planet. At $3^h\ 55^m\ 50^s$ it appeared to have vanished. Thirty seconds afterwards the fourth began to come into view at the opposite side of the planet; so that as viewed with a telescope of the size I was employing ($3\frac{1}{4}$-in. Equatorial, power 180), the planet for half a minute appeared denuded of his satellites; at $4^h\ 13^m\ 40^s$ A.M. the first reappeared.

Melplash Vicarage,
Bridport: Oct. 27.

Elliptic Elements of Comet 1882, *I.* By F. J. Parsons.

(*Communicated by Prof. Safford.*)

The accompanying set of elements was derived from the following six normal places :—

G.M.T.	Mean R.A. 1882·0.	Prob. Error.	No. of Obs.	Mean δ 1882·0.	Prob. Error.	No. of Obs.	Time of Normal Places.
Mar. 26·5	271 36 46·9	±0·71	63	37 15 15·6	±0·41	61	Mar. 19–Apr.
Apr. 12·5	281 22 16·7	±0·20	70	49 49 15·1	±0·66	70	Apr. 4–Apr. 21
May 25·5	55 55 34·2	±0·45	40	59 36 4·1	±0·28	40	May 21–May 28
June 2·5	66 45 42·3	±0·56	18	44 36 27·1	±0·53	17	June 1–June 5
July 9·5	156 59 16·35	±0·59	27	9 45 17·5	±1·3	27	July 8–July 17
Aug. 7·5	181 46 55·5	±1·17	12	4 14 3·7	±1·3	12	Aug. 1–Aug. 16

From the 2nd, 3rd, and 5th of these normal places a preliminary set of elements was computed according to the methods given in Gauss's *Theoria Motus* as follows :

$$T = \text{June } 10{\cdot}52908$$
$$\log. q = 8{\cdot}7836381$$
$$\log. e = 9{\cdot}9999998$$

$$\left.\begin{aligned} \Omega &= 204^\circ\ 56'\ 18''{\cdot}61 \\ \omega &= 208\ 59\ 38\ 17 \\ i &= 73\ 48\ 34{\cdot}88 \end{aligned}\right\} \text{Mean Eq. 1882·0}$$

Rectangular Equatorial Coordinates.

$$x = r[9\ 9611128] \sin (126^\circ\ 22'\ 53''{\cdot}24 + v)$$
$$y = r[9{\cdot}8608368] \sin (\ 61\ 11\ 47{\cdot}56 + v)$$
$$z = r[9{\cdot}9021136] \sin (196\ 51\ 24{\cdot}51 + v)$$

With these elements, considering the excentricity equal to unity, comparison was made with all six normal places in order to make the final corrections to the preliminary orbit by means of a least-square solution.

A computation in duplicate by two independent methods gave the following twelve equations of condition given in logarithmic form.

(x)	(y)	(z)	(u)	(v)	(w)	(n)	
9·16489n	9·27446	9·95933	9·08991n	9·46518	9·44609n	0·27560	$=0$
8·41902n	8·98582	9·70896	9·97296	9·83479n	9·81569	0·72835	$=0$
9·36391n	9·34675	9·97901	9·52692n	9·31175	9·32212n	8·58790	$=0$
8·75669n	8·80395	9·44677	8·46007	9·87899n	9·88936	9·73240	$=0$
8·47717	9·19942n	9·68374n	9·84899n	9·39972n	9·61464	0·16810n	$=0$
9·84246	9·05283n	9·23382n	9·84595	7·49914n	7·71406	0·12710n	$=0$
9·07512	9·14371n	9·48881n	9·48238n	8·97764n	9·37563	0·48150n	$=0$
9·91297	8·85165n	8·76015n	9·49119	8·15680n	8·55479	0·47860n	$=0$
9·49764n	9·12382n	9·58522	9·60400	9·44058	8·86482	9·03510n	$=0$
8·38859	9·19260n	9·78999	0·11026n	9·44974n	8·87398n	9·23040n	$=0$
8·99356n	8·99621n	9·62963	8·81397	9·61626	8·71295	0·65390n	$=0$
7·44648n	9·07909n	9·77796	0·16787n	9·52880n	8·62549n	0·78890	$=0$

Where

$$x = 10000\, d\mathrm{T}$$

$$\mathrm{M}\sin y = d\log. q \text{ (Briggian) or } y = \frac{dq}{q\cdot\sin 1''}$$

$$z = d\chi' = d\omega' + \cos i' d\Omega'$$

$$\sin u = de \text{ or } de = \frac{u}{\sin 1''}$$

$$v = d\Omega'$$

$$w = di'$$

It was not thought worth while to apply weights systematically according to the number of observations, but as the last normal place seemed to have considerably less precision than the others, the last two equations were given a weight of 0·5012 log. 9·70000 as a convenient approximation to a weight of one-half. The above equations of condition give the following normal equations:—

1·3521χ	−0·2004y	−0·7279z	+0·5948u	−0·1752v	+0·0742w	−4·0124n	$=0$
−0·2004	+0·2147	+0·3884	+0·2805	+0·0471	−0·0861	+1·8309	$=0$
−0·7279	+0·3884	+3·2376	−0·7158	−0·0294	−0·1974	+7·4300	$=0$
+0·5948	+0·2805	−0·7158	+5·1019	+0·1672	+0·5524	+0·3768	$=0$
−0·1752	+0·0471	−0·0294	+0·1672	+1·5376	−1·2257	−4·7598	$=0$
+0·0742	−0·0861	−0·1974	+0·5524	−1·2257	+1·3913	+1·7076	$=0$

Giving the following values for the unknown quantities:—

$$x = \quad 4''\!\cdot\!4771 \pm 1''\!\cdot\!468$$
$$y = \quad 2\cdot4213 \pm 4\cdot214$$
$$z = -\ 1\cdot4295 \pm 0\cdot875$$
$$u = -\ 2\ 2662 \pm 0\cdot877$$
$$v = +\ 10\cdot952 \pm 2\cdot495$$
$$w = +\ 9\cdot035 \pm 2\cdot739$$

Substituting these values in the equations of condition gives for the sum of the squares of the residuals $[vv]=22{\cdot}02$. In the solution of the normal equations $[nn]=22{\cdot}09$.

From these unknown quantities the following corrections to the preliminary elements are found.

$$dT = +\ 0{\cdot}000448 \pm 0{\cdot}000147$$
$$d\log q = +\ 0{\cdot}0000051 \pm 0{\cdot}0000089$$
$$d\omega' = -\ 8''{\cdot}024 \pm 2''{\cdot}644$$
$$de = -\ 0{\cdot}00001098 \pm 0{\cdot}00000425$$
$$d\Omega' = +\ 10'.952 \pm 2''.495$$
$$di' = +\ 9{\cdot}035 \pm 2{\cdot}739$$

These corrections give, as the most probable values of the elliptic elements—

$$T = \text{June } 10{\cdot}52953,\ \text{G.M.T.} \pm 0{\cdot}00015$$
$$\log q = 8{\cdot}7836432 \pm 0{\cdot}0000089$$
$$e = 0{\cdot}99998902 \pm 0{\cdot}00000425$$

$\omega = 208^\circ\ 59'\ 33''{\cdot}72$	Mean Equinox and Ecliptic 1882·0.	$\omega' = 196^\circ\ 51'\ 16''{\cdot}49 \pm 2''{\cdot}644$	Referred to Equator.
$\Omega = 204\ 56\ 29{\cdot}49$		$\Omega' = 210\ 29\ 12{\cdot}25 \pm 2{\cdot}495$	
$i = 73\ 48\ 41{\cdot}82$		$i' = 52\ 57\ 41{\cdot}04 \pm 2{\cdot}739$	

Rectangular Equatorial Coordinates.

$$x = r[9{\cdot}9611023] \sin(126^\circ\ 22'\ 49'{\cdot}33 + v)$$
$$y = r[9{\cdot}8608362] \sin(\ 61\ 11\ 58{\cdot}04 + v)$$
$$z = r[9{\cdot}9021280] \sin(196\ 51\ 16{\cdot}49 + v)$$

These elements correspond to a period of about 400,000 years.

Recomputing the position of the comet for the dates of the six normal places, and comparing, gives the following results—the column headed "v" being the residuals obtained by substituting in the equations of condition the values found above for the unknown quantities.

	$\delta\alpha\cos\delta$ $(c-o)$	v	$d\delta$ $(c-o)$	v
Mar. 26·5	+1·36	+1·34	+1·01	+1·00
April 12·5	−0·86	−0·71	−1·31	−1·31
May 25·5	+1·53	+1·52	+0·19	+0·17
June 2·5	−0·61	−0·60	+0·04	+0·03
July 9·5	+0·37	+0·38	−2·33	−2·16
Aug. 7·5	−0·91	−0·95	+4·30	+4·24

The planetary perturbations, being small, have not as yet been taken into account, as I intend to make a more complete discussion of the comet when all the observations have been published.

Field Memorial Observatory,
Williamstown, Mass.

Observations of Comet b, 1883 (*Pons-Brooks*), *made at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

The observations on September 5 and 26 with the South-East Equatorial (aperture 12·8 inches), and those on October 21 and 29 with the East or Sheepshanks Equatorial (aperture 6·7 inches), were all made by taking transits over two cross-wires at right angles to each other, and each inclined 45° to the parallel of declination.

Observations of Comet b, 1883 (*Pons–Brooks*), *with the S.E. Equatorial. Aperture* 12·8 *inches.*

Greenwich Mean Solar Time 1883, Sept. d h m	Obs.	δ − ✶ R.A. m s	Corr. for Parallax in R.A. s	δ − ✶ N.P.D. ′ ″	Corr. for Parallax in N.P.D. ″	No. of Comp.	App. R.A. h m s	App. N.P.D. ° ′ ″	
5 14 11	M.	+0 42·44		+1 21·0		5	16 33 12·10	25 33 32·2	*a*
		−0 24·90		+8 26·8		5			*b*
26 9 55	M.	+0 15·31	+0 35	+1 20·1	−1·5	4			*c*
		−0 32·44	+0 35	+8 29·8	−1·5	4	16 25 47·29	30 5 54·8	*d*

Assumed Mean Places of the Comparison Stars.

Star.	Star's Name.	R.A. 1883·0. h m s	N.P.D. 1883·0. ° ′ ″	Authority.
a	Oeltz. Arg. (N) 16374	16 32 29·78	25 32 31·6	Oeltz. Arg. (N) 1842
b	Anonymous			
c	,,			
d	Oeltz. Arg. (N) 16270	16 26 20·33	29 57 42·7	Oeltz. Arg. (N) 1842

Sept. 5. The comet was a very diffused and exceedingly faint object, becoming more and more difficult as it got lower. The positions are therefore exceedingly rough.

The observations are not corrected for parallax. The effect of refraction is insensible.

Sept. 26. Comet fairly bright; round; no tail; central condensation. Two transits of the first and second edge of the comet were taken to determine the diameter. The mean of these transits gives for the apparent diameter 2′ 21″·0.

The star *c* was very faint.

The observations are corrected for parallax. The effect of refraction is insensible.

Observations of Comet b, 1883 (*Pons—Brooks*), *with the East Equatorial. Aperture* 6·7 *inches.*

Greenwich Mean Solar Time. 1883, Oct.	Obs.	δ − ✳ R.A.	Corr. for Par. in R.A.	δ − ✳ N.P.D.	Corr. for Par. in N.P.D.	No. of Comp.	App. R.A.	App. N.P.D.	
d h m		m s	s	′ ″	″		h m s	° ′ ″	
21 11 9	A.D.	−0 46·39	+0·36	+ 4 28·6	−2·5	2	16 46 12·20	35 19 20·8	*e*
11 12		−3 45·14	+0·36	+ 7 6·2	−2·6	1	16 46 17·42	35 20 27·0	*f*
11 38		+2 14·35	+0·35	− 3 42·7	−2·8	3	16 46 16·77	35 19 52·1	*g*
29 6 34	A.D.	+1 26·66	+0·33	+ 3 31·6	−1·2	3	16 58 51·16	36 50 18·0	*h*
6 49		−2 13·91	+0·34	− 6 26·3	−1·4	2			*i*
7 21		−2 35·65	+0·35	+13 43·5	−1·7	2	16 58 43·20	36 49 55·1	*j*

Assumed Mean Places of the Comparison Stars.

Star.	Star's Name.	R.A.	N.P.D.	Authority.
		h m s	° ′ ″	
e	Arg. Z + 54° − 1839	16 46 59·23	35 15 7·8	Bonn Obs., vol. v.
f	Arg. Z + 54° − 1846	16 50 3·18	35 13 36·8	,,
g	Oeltz. Arg. (N) 16534	16 44 3·07	35 23 49·9	Oeltz. Arg. (N) 1842
h	Arg. Z + 53° − 1910	16 57 25·10	36 47 1·5	Bonn Obs., vol. v.
i	Anonymous			
j	Oeltz. Arg. (N) 16790	17 1 19·44	36 36 27·1	Oeltz. Arg. (N) 1842

Oct. 21. Comet very faint and difficult to observe; has a stellar nucleus.

Stars *e* and *f* about the tenth magnitude; *c* about the eighth.

Oct. 29. Comet faint and difficult to observe.

The observations are corrected for parallax. The effect of refraction is insensible.

The initials A.D. and M. are those of Mr. Downing and Mr. Maunder.

Royal Observatory, Greenwich:
1883, *Nov.* 9.

Observations of the Variable Star R Carinæ from May 1880 *to Sept.* 1883. By John Tebbutt.

My attention was first drawn to this star in May 1880 by the remarks of Dr. Gould in the *Uranometria Argentina*, who was, I believe, the first to point out its variability. It is synonymous with the star numbered 3932 in Lacaille's Catalogue of 9766 stars. Perceiving that it was one of the most remarkable variables beneath the horizon of northern Observatories I at once resolved to follow its variations systematically. I have therefore recorded its magnitude at every suitable opportunity. During the visibility of the star to the unassisted eye my comparisons were made with a selection of neighbouring stars from the *Uranometria*; when the variable became telescopic they were

made with certain stars comprised with it in the same low-power field of my telescopes of $3\frac{1}{4}$ and $4\frac{1}{2}$-in. aperture. In order that the precise value of my estimates near the minimum may be understood by any future astronomer who may continue the observations of this star, I have appended a list of the small comparison stars, giving their assumed magnitudes and their approximate coordinates in R.A. and N.P.D., with reference to the variable itself. I may state that the smallest stars in the list—namely, those of the 9·2 magnitude—can just be seen with the aperture of the $4\frac{1}{2}$-in. telescope reduced to one inch. They are also found to be about equal to the average stars of the ninth magnitude in *Oeltzen-Argelander's Zonen Beobachtungen*, 15° *to* 31° *Sud. Dec. für* 1850. The brightest comparison in the field is Lacaille 3993, whose magnitude 6·9 is adopted from the *Uranometria*. The variable is red through all its stages, and it will be seen that although the star does not vary much from the ninth magnitude at the minimum, the value of the maximum magnitude varies considerably. Of the four maxima observed here, that of December 1880 was much the brightest. The variations about the maximum appear to be more rapid than those about the minimum. The following table exhibits the concluded magnitudes of the variable during the period May 1880–Sept. 1883; and as they are the results of very careful comparison, I trust they will prove an acceptable contribution towards data for an investigation of the period and other elements of this remarkable star. I shall continue the observations, more especially about the epochs of maximum and minimum. Comparing my own estimates with those recorded for 1871–1874 in the *Uranometria*, I conclude that the probable period from maximum to maximum is about 313 days. This conclusion, it will be seen, agrees with that already published by me in the *Journal of the Royal Society of New South Wales* for 1881.

Windsor, N S. Wales:
1883, *Sept.* 5.

Concluded Magnitudes of R Carinæ.

Date.	Mag.	Date.	Mag.	Date.	Mag.
1880, May 11	8·2	1880, Aug. 9	9 0	1880, Nov. 14	6·0
12	8·3	12	9·0	15	6·0
18	8·3	22	9·0	17	5·9
28	8·5	Sept. 1	8·8	20	5·7
June 9	8·9	18	7·5	24	5·4
28	9·0	30	7·0	30	5·3
July 5	9·2	Oct. 10	6·9	Dec. 1	5·2
12	9·1	26	6·7	4	5·1
20	9 0	27	6·7	10	4·6
26	9·1	30	6·7	12	4·4
Aug. 4	9·1	Nov. 1	6·6	14	4·4

Date.	Mag.	Date.	Mag.	Date	Mag.
1880, Dec. 16	4·3	1881, Aug. 11	8·2	1882, June 14	8·6
18	4·4	19	8·2	24	8·3
19	4·4	30	8·1	July 29	7·2
22	4·5	Sept. 16	7·4	Aug. 10	6·0
25	4·5	Oct. 8	5·7	21	5·0
26	4·7	11	5·5	30	4·9
30	4·9	21	5·4	Sept. 2	4·9
1881, Jan. 1	4·9	27	5·4	6	4·9
5	4·9	Nov. 7	5·5	13	5·1
6	4·9	13	5·9	23	5·4
8	5·0	17	6·3	Oct. 6	5·7
15	5·2	18	6·2	10	6·5
19	5·4	22	6·3	Nov. 21	7·6
26	6·1	Dec. 3	6·9	Dec. 12	9·8
29	6·0	10	7·0	18	8·5
Feb. 10	6·4	19	7·6	29	8·8
15	6·6	1882, Jan. 2	8·3	1883, Jan. 12	9·1
26	7·0	9	8·5	16	9·1
Mar. 1	7·0	18	8·6	25	9·2
7	7·5	23	8·7	Feb. 7	9·3
14	8·0	31	8·9	13	9·2
18	8·2	Feb. 10	9·0	26	9·2
24	8·4	15	9·0	Mar. 4	9·2
30	8·6	20	9·1	10	9·1
Apr. 7	8·7	24	9·1	28	9·0
13	8·8	Mar. 6	9·2	Apr. 1	9·0
19	8·8	10	9·2	27	8·4
28	9·0	17	9·2	June 14	6·0
May 4	9·1	22	9·2	26	5·5
10	9·1	27	9·3	July 3	5·0
16	9·1	Apr. 4	9·2	7	5·1
21	9·1	5	9·2	8	5.0
June 1	9·2	9	9·2	12	5.0
8	9·3	15	9·3	17	5·1
20	9·1	20	9·3	20	5·2
27	9·0	24	9·2	24	5·2
July 6	8·9	May 5	9·2	27	5·2
14	8·9	11	9·1	29	5·2
20	8·8	20	9·1	Aug. 1	5·5
29	8·7	June 4	8·8	6	5.7
				Sept. 3	6·9

Coordinates in R.A. and N.P.D. of the Comparison Stars with reference to R. Carinæ, together with the Adopted Magnitudes of the Comparison Stars.

Comparison Star.	Adopted Magnitude.	R.A.	N.P.D.
		m s	′ ″
No. 1 (Red Star) ...	8·7	1 31·4 E.	26 28 S.
2	9·2	1 32·1	8 5 S.
3	8·6	1 52·0	20 24 N.
4	9·2	2 56·1	0 45 S.
5	8·5	3 8·4	20 13 N.
6	9·2	3 52·6	10 8 S.
7	9·2	4 30·0	9 0 N.
8	8·0	6 4·9	14 41 N.
9	9·1	6 46·2	3 52 S.
10	8·0	6 46·8	14 51 N.
11	8·5	7 8·7	27 17 S.
12 (Lacaille 3993) ...	6·9	7 23·5	8 31 S.
13	8·9	8 2·2	12 9 S.
14	8·8	9 34·7	6 54 N.
15	8·6	10 8 0	3 33 N.

Note.—The position of star No. 7 is derived from alignments with the other stars.

Errata in my communications in vol. xliii. of the Monthly Notices of the Royal Astronomical Society.

Page 279. *For* 0ˢ·7 *read* 0ˢ·1.
„ 386. R.A. parallax factor for Oct. 26; *for* −8·7083 *read* −8·7089.
„ 387. Comparison Star for Nov. 14; *for* 31 *read* 35.
„ 389. Comet's App. N.P.D. for Dec. 29; *for* 119° 51′ 19″ *read* 119° 51′ 9·1″.
„ 393. Opposite to Star No. 54; *for* 1880, 3240 *read* 1860, 3240.

Measures of Southern Double Stars. By E. B. Powell.

In the *Monthly Notices* for June 1870, in which appeared my last published elements of the orbit of *α Centauri*, I mentioned my intention of communicating at a later period the details of the double star observations I was then engaged in taking. Circumstances prevented me from carrying out the plan I had formed of securing a considerable number of measures of different southern binaries; and, on my return to Europe in 1875, I thought it scarcely worth while to trouble the Society with the limited number of observations I had taken. As, however, Dr. Elkin applied to me some time ago for my unpublished

detailed observations of *α Centauri*, it occurs to me that I may as well enable the Society to place them on record, should it appear advisable to do so; I therefore do myself the pleasure of forwarding them. Along with the measures of *α Centauri* are three other southern stars, and a few observations of *η Cassiopeiæ*. The measures now placed before the Society embrace all my Madras results subsequent to those recorded in vol. xxxii. of the *Memoirs*.

Bath, Sept. 24, 1883.

Star.	Pos.	No. Obs.	Dist.	No. Obs.	Epoch.
	°		″		
η Cassiopeiæ	122·7	10	6·42	4	1863·868
	122·8	6			1863·903
	123·6	6	6·63	6	1864·109
	123·6	8	6·78	10	1864·125
Mean	123·1	30	6·65	20	1864·001
	133·15	5			1870·058
	134·17	7	6·28	8	1870·066
	133·4	5	6·3	10	1870·071
	133·45	7	6·5	8	1870·074
	133·1	8	6·45	8	1870·079
Mean	133·4	32	6·39	34	1870·07
	137·6	6	5·9	6	1871·077
	136·96	8			1871·123
Mean	137·4	14	5·9	6	1871·1
p (6) Eridani	250 8	10	5·17	10	1863·004
	251·3	6	4·77	10	1863·015
	250·9	5	4·88	10	1863·02
	250·7	9	4·61	8	1863·029
Mean	250·9	30	4·9	38	1863·017

Star.	Pos.	No. Obs.	Dist.	No. Obs.	Epoch.	
	°		″			
p (6) Eridani	243·0	6			1870·048	
	243·3	7			1870·063	
	243·2	3	5·55	10	1870·066	
	243·0	7			1870·071	
	242·7	6			1870·088	
	242·8	5	5·74	10	1870·099	
Mean	243·0	34	5·7	20	1870·072	
	241·4	5	5·6	6	1871·005	
	241·4	12	5·2	8	1871·077	
	241·7	10	5·4	10	1871·088	
	241·6	6			1871·09	
	241·5	7	5·8	8	1871·099	
	241·9	5	5·37	8	1871·104	
Mean	241·6	45	5·46	40	1871·077	
γ Centauri	6·2	5			1870·187	Distance about $1\frac{1}{2}''$ or $1\frac{1}{4}''$ by estimation.
	7·4	6			1870·198	
	8·0	5			1870·244	Distance measures beyond telescope.
	6·6	5			1870·252	
	7·65	4			1870·255	
	6·75	8			1870·26	
Mean	6·85	33			1870·233	
	8·1	6			1870·971	
	7·03	6			1871·061	
	6·7	7			1871·073	
	5·7	10			1871·092	
	5·85	7			1871·097	
Mean	6·16	36			1871·059	

Star.	Pos.	No. Obs.	Dist.	No. Obs.	Epoch.	
	°		″			
α Centauri	1·2	10	7·35	10	1863·004	
	·83	12	7·4	10	1863·009	
	2·02	6			1863·024	
	1·3	6	7·4	6	1863·028	
	·9	10	7·04	10	1863·045	
	2·2	15			1863·056	$3\frac{1}{2}$ wrong; $-\frac{1}{2}$ much worse.
Mean	1·4	59	7·2	36	1863·028	
	5·9	10	7·67	8	1864·002	
	5·6	10			1864·094	
	5·6	8	7·9	8	1864·116	
	5·8	10	7·7	26	1864·121	
	5·6	6			1864·132	
	5·4	10	8·02	10	1864·152	$7\frac{1}{2}$ wrong, but not very bad; $3\frac{1}{2}$ much worse.
	5·9	10	7·9	18	1864·156	
Mean	5·7	64	7·85	70	1864·11	
	11·18	5	8·87	6	1866·056	
	11·2	10	9·5	6	1866·061	
	11·0	9	9·37	10	1866·072	
Mean	11·1	24	9·3	22	1866·063	
	17·9	8	10·6	8	1869·127	
	18·0	14	9·9*	12	1869·138	
Mean	17·97	22	10·4	20	1869·132	

* Distance clipped as much as the eye could bear without being offended. Intended to try on another night how wide a distance the eye could bear, but did not carry out intention. Gave second night only $\frac{1}{3}$ the weight of first night.

Star.	Pos.	No. Obs.	Dist.	No. Obs.	Epoch.	
	°		″			
α Centauri	21·23	5	10·2	6	1870·012	
	20·7	10	10·29	10	1870·015	
	21·0	5	9·97	10	1870·018	Stars unsteady.
	20·43	15	10·25	32	1870·059	
	19·75	5	10·16	10	1870·067	Stars unsteady.
	20·28	8			1870·07	
	20·23	5	9·99	10	1870·073	Stars at times flaring.
	19·72	10	10·26	10	1870·081	
	20·28	5	10·46	20	1870·083	Stars beautiful.
	20·65	8	10·11	10	1870·187	
	20·27	10	10·38	20	1870·193	
	20·53	7	10·28	14	1870·198	
	21·27	7	10·08	10	1870·242	
Mean	20·45	100	10·24	162	1870·1	
	22·07	5			1870·591	
	21·75	5	9·88	8	1870·599	
	21·83	7	10·07	10	1870·602	
	22·12	5	10·16	10	1870·611	
	21·5	7	10·27	10	1870·635	Daylight.
Mean	21·8	29	10·09	38	1873·608	
	22·98	5	9·9	10	1870·971	
	22·9	5	9·8	10	1870·981	
	23·1	5	9·8	6	1870·984	Stars unsteady. Daylight.
	23·25	6	9·96	18	1871·061	Some night, some day.
	23·29	18	9·77	20	1871·073	Some night, some day. Some E., some W.
	23·33	7	10·0	10	1871·078	
	22·8	20	9·9	20	1871·092	
	22·7	7	9·93	20	1871·094	Daylight.
	23·02	7	10·07	10	1871·097	East.
	22 95	7	9·8	18	1871·102	West.
	23·03	5	9 92	20	1871·105	West.
Mean	23·01	90	9·89	162	1871·05	

Star.	Pos.	No. Obs.	Dist.	No. Obs.	Epoch.	
	°		″			
α Centauri	23·0	7	9·8	10	1871·215	
	22·7	8	9·83	10	1871·22	
	23·2	5	10·0	6	1871·307	
	24·3	5	9·8	10	1871·32	
	23·8	7	9·9	20	1871·326	Some E., others W.
	24·2	8	9·66	10	1871·389	
	24·9	5	9·9	20	1871·391	
Mean	23 7	45	9·8	86	1871·31	
γ Coronæ Aust.	318·5	6			1863·775	
	317·6	12			1863·849	
	318·8	7			1863·857	
	318·4	5			1863·865	
Mean	318·1	30			1863·836	
	285·5	5			1870·187	Taken with a lower power than usual, and therefore perhaps subject to extra error.
	287·6	7			1870·193	
Mean	286·9	12			1870·19	
	281·9	12			1871·22	

On Humidity as a Cause of Variation of Rate in Chronometers.

By Major-General J. F. Tennant, R.E., F.R.S.

About the end of March, 1882, I borrowed from the Government stores a chronometer by Thomas Fletcher of London, No. 2684; it had been some time in India, but had not been cleaned since its arrival, and was said to have a good rate. When it came to me the rate was about $-6^{s}\cdot5$ (gaining), and this it seemed to keep fairly till the end of May (149^{d}). (I shall use the days of the year frequently, as I can readily take them from my graphic projection of data.) Then the rate suddenly fell to $-2^{s}\,0$ between 150^{d} and 170^{d}, rose nearly a second for a week, and then with small variations continued to fall till about 270^{d}, when it became insensible. At 290^{d} it rose a little, but shortly after I left Calcutta for a short holiday, and missed a period

which would have been interesting. Of course, the watch ran down, and when I returned and started it again, after some unsteadiness, the rate was $-2\frac{1}{4}^s$ from 310^d to 316^d, and it rose to $-8^s{\cdot}0$ about 330^d to 350^d on the average. It again accidentally ran down, but was started towards the end of the year, and in the beginning of 1883 the rate was $-7^s{\cdot}8$, and it gradually rose numerically till in the period 59^d–65^d it was $-9^s{\cdot}2$. From 65^d–74^d the rate fell to $-6^s{\cdot}8$, and, after a slight rise, it gradually fell from 85^d till about 180^d it became $+0^s{\cdot}2$, and the change went on till, about the beginning of the present month (245^d), it was $-2^s{\cdot}6$.

I have compared these rates with a plot of the published daily mean temperatures at the Meteorological Observatory. Of course that is not quite satisfactory; but though at first sight it would seem that the rate depends on temperature, farther examination shows that it can only do so to a small extent, and confirms the belief I had from general impressions, and that which was formed by others who used it, that the rate does not depend on temperature. Except occasionally, when carefully carried by myself to a place where I could observe the Port Time Ball, which has been used for determining errors, the chronometer has stood in a room sheltered from sun, but always open to the air more or less. It is, however, certainly cooler in the hot season, and probably warmer in the cold season, than the outer air, and with a far more equable temperature. It has stood, too, in its outer case.

There was a cold period in 1882, about 130^d, when the mean of some days of temperature was about 77° F., and the rate was $-6^s{\cdot}7$. It was the same at 120^d, when the average was about 85° F., and about 140^d, when it was $-6^s{\cdot}0$. On the other hand, about 270^d, when the rate was $0^s{\cdot}0$, the temperature was about 83°·5 F. About 1883, 30^d, the temperature averaged barely 60°, while the rate was about $-8^s{\cdot}0$ on the average. When the rate was $-9^s{\cdot}2$ the temperature was about 78° F., whereas recently, when the rate has been losing rather than gaining, the temperature is about 82° F.

But there is no doubt that there is, however, a periodic change of rate, and I believe the cause to be *humidity*. My first suspicion was raised by the sudden fall of rate this year being coincident with the first heavy rains producing great damp, and the fact that it was so last year, and that the whole period of low gaining-rate was that of the rains, while the lowest was the warm time at the end of the rains, when the soil is loaded generally with moisture. The same phenomenon has recurred. It is, however, much more difficult to compare the supposed cause and effect without special arrangements. In my room the damp rises largely from the ground, and after very heavy rain the floor is discoloured, or even glistening with moisture in the early morning. The humidity of the air taken at the Observatory is thus no real measure of that of the room, but in any case

it is doubtful whether air-humidity could be more than a rough guide.

If, as I suspect in this case, the oil on the arbours of the balance be hygroscopic, it is easy to see that it may become more fluid in damp weather, the arc of oscillation will increase, the balance vibration take longer, and the watch lose; but the momentary humidity of the air will not correspond to the rate as the temperature does more or less. Such a general accordance as I have shown seems the only possible result of comparison. But there seems in this case to me an undoubted connection, and it may be worth making special experiments in the following directions:

1st. Are chronometer oils, or any of them, hygroscopic?

2nd. Can they become so by exposure to a tropical climate? And in this last case I conceive that the climatic influence cannot be imitated in Europe. The effect of the heat, and probably the light, are very destructive of some materials. For instance, vulcanised indiarubber will not bear exposure in India, though it seems to answer in Europe even in heat and damp.

Lastly, in estimating the effect of humidity on a given chronometer, it will probably be best to use one of the old hair or grass hygroscopes for the humidity, placing it in the case enclosed with the watch.

P.S. As I shall be leaving India soon I shall not be in a position to investigate any farther with this watch.

H. M.'s Mint, Calcutta:
1883, *September* 14.

Showers of Large Meteors. The Muscids (Oct. 17–22) and Herculids (Oct. 17–26). By W. F. Denning.

A large meteor seen here on October 17, 1883, at $9^h\ 33^m$, as it traversed a nearly vertical path of 28° amongst the stars of *Hercules*, evidently belonged to a radiant point between *Aries* and *Taurus*, forming an early member of the prominent shower of Muscids (Oct. 25–Nov. 6), to which I called special attention in the *Monthly Notices*, vol. xlii. pp. 34–7. I had no idea, however, that this shower occurred with considerable brightness simultaneously with the Orionids, but on projecting the catalogued paths of a great many fireballs observed during the October meteoric epoch (Oct. 17–22) I found that the principal radiant lies at a very definite point S. of *Musca*, in the E. region of *Aries*, and close to the diverging focus of the later shower above referred to. In fact, this particular stream apparently gives many meteors of the finest class from about the middle of October

to the end of the first week in November, and like its companion, though somewhat later, shower the Taurids, is of long continuance.

The following afford examples of these early and often brilliant Muscids:—

Year 1800+ and Date.			Mag.	Observed Path From α	From δ	To α	To δ	Length.	Observer.
49	Oct.	17	Fireball.	76°	+55°	188°	+41°	68	Heis, Aachen.
54		21	♀	72	+14	83	+12	11	Heis, Münster.
70		20	♃	10	+44	314	+53	38	Jadanza, Napoli.
70		22	♃	85	−11	90	−14	6	Maggi, Volpeglino.
72		19	♀	157·5	+71·3	183·3	+61·2	15	Holetschek, Wien.
77		20	♃	336	+22·5	293	+15·5	41	Denning, Bristol.
78		21	♀	5	−15	343	−32	27	Sawyer, Camb. U.S.A.
78		22	♃	3	−10	346	−28	25	„
83		17	♀	259	+48·5	241·5	+24	28	Denning, Bristol.

Radiant point at 40° + 20°.

A careful search through all the published catalogues of observers would doubtless reveal many other brilliant meteors belonging to this system.

The shower seems to have been especially active in 1871. Prof. Herschel at Hawkhurst* saw six meteors (on Oct. 14, 11^h to 12^h), "as bright as or brighter than first mag. stars, radiating with considerable accuracy from a point near the head of *Aries*, and close to the point of first appearance on this date of the radiant R_3 in *Musca* which appears to contribute bright meteors from the direction of this constellation during the principal meteor-showers of October, November, and December, but from which so many bright meteors in one hour as those seen at Hawkhurst on the above date form an exceptional display. Another meteor like one noted on this date, as bright as *Sirius*, proceeded from the same radiant point, passing overhead at Hawkhurst, and leaving a faint streak at $11^h\ 45^m$ P.M. on Oct. 19, and two scarcely less brilliant members of the same meteor-shower appeared with short courses and slow motion near the radiant point on Oct. 21." The great meteor of Oct. 19, 1877, $6^h\ 13^m$, may also have belonged to this stream, as the radiant point roughly inferred from a few uncertain observations was at 20° + 15°. The region of *Aries* is very rich in showers during October, and there is considerable difficulty in tracing their individual characters. In 1877, Oct. 28, Nov. 13, I saw a dis-

* B.A. Report on Meteors, 1872, p. 92.

play of eleven slow meteors from the point 30°+16°, and in 1879 Oct. 14–20 recorded thirty-seven slow and generally small meteors from a radiant at 31°+9°, or 13° S. of *α Arietis*. Mr. Corder has also observed * many of the shooting stars of the latter shower, which also have been seen by Col. Tupman, notably in 1869, Oct. 13,† from the point 28°+10°. But these showers are probably quite distinct from the Muscids, relatively to which they supply meteors of far inferior magnitude.

I noticed this shower as early as Oct. 8, in 1877, when it furnished a display of eight short, quick meteors. On Oct. 12, 1868, it was splendidly seen by Sig. Zezioli at Bergamo. Twenty-two meteors (six per hour) were traced to a radiant point well-defined to within 1° or 2°, at 53°+27° (Schiaparelli). The latter position, though several degrees E. of the average centre of this shower, undoubtedly represents its very active return in that year. It evidently varies to a considerable degree in different years; for though at about the middle of October 1879 a large number of meteors were registered at Bristol, this radiant point gave no visible indication of activity.

It seems desirable to summarise the various determinations of the radiant point of this special meteor-stream.

Year.	Epoch.	Radiant. α δ	No. of Meteors.	Observer or Authority.
	Oct. 14–Nov.	46°+27°		Greg and Herschel.
1868	12	53+27	22	Schiaparelli and Zezioli.
1872	29–Nov. 13	45+26	7	D. (from Italian obs.)
1876	14–15	46+26	13	D.
1876–9	Oct.–Nov.	43+15	34	Corder.
	„	41+13	13	„
1877	Oct. 8	47+28	8	D.
1877	28–Nov. 13	43+22	31	D.
1878	21–22	47+27	4	Sawyer.
1879	19	44+18	4	„
	20–31	40+21	18	D. (from Foreign obs.)
1879	Nov. 12–14	46+21	19	D.
1880	28	40+21	8	Weiss.
	Oct. 17–22	40+20	9	D. (rad. of fireballs).
	25–Nov. 6	48+22	17	„

Mean of 15 radiants = 44°·6 + 22°·3, Oct. 8–Nov. 28.

* *Monthly Notices*, vol. xl. p. 137. Radiants, Nos. 71, 72, and 73.
† See No. 93 of his Catalogue of Radiant Points.

My recent investigation of the bright meteors of Oct. 17–22 enabled me to identify many fine Orionids from their recorded paths, but the radiant point of this well-known periodical shower is already sufficiently determined. I also found several bright Gemellids amongst the observations, indicating a radiant at 102°+26°.

The shower in *Hercules* occurring also at the October epoch is, however, comparatively unknown. It is situated at 247°+41°, near *η Herculis*, some 64° N.E. of the Sun's place, and in a region almost devoid of meteoric radiants at this time of the year. My attention was first attracted to this shower in 1876, but I had little more than a suspicion of its existence. I saw nothing of it in the several succeeding years, my observations being invariably directed to the eastern sky where, had any Herculids appeared, they would probably escape identification owing to their great distance from the radiant point.

But on Oct. 26, 1883, at $9^h\ 17^m$, while walking along a dark lane in a northern suburb of this city, I suddenly became aware of a brilliant flash illuminating objects around with startling distinctness, and followed by a more prolonged outburst of light. Immediately looking upwards I saw the nucleus of a large fireball passing close to *α Cephei* near the zenith. As I watched it disappear, it gave two other flashes, and then died out suddenly, leaving a broken streak, the brilliant sections of which marked the points where the succession of outbursts had occurred. The meteor rose upwards, traversing a path, as I roughly estimated it, of 24°, and its motion towards the end consisted of a series of spurts, accompanied with brilliant discharges. The streak became extinct in about four seconds, and soon afterwards the sky was covered with clouds, so that I found it impracticable to maintain a watch for further meteors of the same stream, the radiant point of which must evidently have occupied a position in the W.N.W. sky amongst the stars of *Hercules*.*

On consulting Heis's *Resultate 43 Jahren 1833–1875, Angestellten Sternschuppen-Beobachtungen*, I find he gives a radiant at

* Several other fireballs appear to have been noticed by different observers on the same date. Mr. D. Cameron says (*Nature*, Nov. 15, p. 56), "At $2^h\ 50^m$ A.M. on Oct. 26, a large ball of fire, apparently seven inches in diameter, illumined the heavens with great brilliancy as it descended from about midway between the third and fourth stars of *Auriga*." The same journal (Nov. 8, p. 44) states that "on Oct. 26, at about 7 P.M., a splendid meteor was seen in the district of Hernosand, Sweden. A traveller on the road to Ragunda says that he suddenly saw the night lit up as in broad daylight, which was caused by a large meteor appearing, with a blinding white lustre, in the zenith, and travelling very rapidly down to the horizon. When halfway, as it appeared to the observer, between the zenith and the Earth, it suddenly burst, throwing a quantity of sparks in every direction." The extremely vague character of these descriptions renders them almost useless, but the observations are worth referring to as showing the prevalence of fireballs on Oct. 26 of this year. It is much to be regretted that in such cases observers generally omit to give those most essential details—the direction and position of the apparent paths.

238° + 51° from 19 meteors seen between Oct. 17 and Nov. 14, and this shower from the extreme N.W. region of *Hercules* is probably the same as that from which the recent fireball took its departure. Prof. N. de Konkoly had also suspected the shower from observations at O'Gyalla on Oct. 22, 1872, and derived the centre at 243° + 42°.* The radiant is well supported by several brilliant meteors recorded at the same station on Oct. 22, 1873, though this corroboration does not appear to have been previously mentioned. It is obvious that this particular stream is one which merits close watching in future years, not only because its gives a profusion of brilliant meteors, but also on account of the comparatively isolated situation of the radiant point. Owing to the latter circumstance this shower, if a prominent one, will admit of very ready determination, as its meteors will show a peculiarity of direction as compared with those proceeding from the large number of radiants clustering in the eastern sky. It will be best observed in the early evening hours, before the radiant falls low on the northern horizon.

The following are a few bright meteors belonging to this system of Herculids (Heis F_9):

Year 1800+ and Date.			Mag.	Observed Path From α	From δ	To α	To δ	Length.	Observer.
53	Oct.	23	1	8°	+34°	18°	+26°	12	Heis, Münster.
60		17	4	237	+32	229	+23	11½	„
63		25	♀	41	+41	43	+31	10	„
63		25	♀	41	+48	44	+39	9	„
73		22	1	321·4	+ 7·0	352·6	−16·6	39	Konkoly, O'Gyalla.
73		22	♀	330·4	+18·5	5·8	−10·8	46	„
83		26	?=½ ☽	288	+56	333	+59	24	Denning, Bristol.

Radiant diffuse near *η Herculis*, 247° + 41°.

The above seems to have furnished large meteors at intervals of about ten years. All those observed appear to have left bright streaks. The reappearance of this shower should be carefully looked for in future years. It is true that at this epoch the Orionids usually monopolise attention, but the radiant in *Orion* does not rise until nearly 9 P.M., so that during the three hours preceding this the observer may be usefully employed in watching the N.W. sky for some indication of the return of this apparently rich shower in *Hercules*.

Bristol: 1883, *Nov.* 8.

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* *Beobachtungen angestellt am Astrophysicalischen Observatorium in O'Gyalla* 1879, p. 70.

Ephemeris for finding the Positions of the Satellites of Mars, 1883–84. By A. Marth.

The major and minor semi-axes a and b of the apparent ellipses described by the satellites, the longitudes $u-U$ of the satellites reckoned in their orbits from the points which are in superior conjunction with the centre of the planet, and the angle of position P of the minor axes of the apparent orbits are approximately the following :—

Greenw. Noon. 1883.	*Phobos.* a_1	b_1	u_1-U	Diff. 2250° +	P	*Deimos.* a_2	b_2	u_2-U	Diff. 570° +
	″	″	°	°	°	″	″	″	°
Dec. 19	15·38	+4·93	36·05	7·68	4·56	38·42	+12·32	271·99	0·25
21	15·64	5·00	133·73	·73	4·62	39·06	12·49	122·24	·30
23	15·90	5·06	231·46	·78	4·65	39·71	12·65	332·54	·36
25	16·16	5·12	329·24	·84	4·65	40·36	12·79	182·90	·41
27	16·42	5·18	67·08	·89	4·61	41·01	12·93	33·31	·47
29	16·68	5·23	164·97	·93	4·54	41·65	13·06	243 78	·52
31	16·93	5·27	262·90	7·99	4·43	42·29	13·17	94·30	·57
1884.									
Jan. 2	17·18	+5·31	0·89	8·05	4·29	42·92	+13·26	304·87	0·63
4	17·43	5·34	98·94	·09	4·12	43·54	13·34	155·50	·68
6	17·67	5·36	197·03	·14	3·91	44·14	13·40	6·18	·74
8	17·90	5·38	295·17	·19	3·67	44·72	13·44	216·92	·78
10	18·12	5·39	33·36	·24	3·40	45·27	13·47	67·70	·83
12	18·33	+5·39	131 60	8·28	3·09	45·79	+13·47	278·53	·88
14	18·53	5·38	229·88	·32	2·75	46·28	13·45	129·41	·93
16	18·71	5·37	328·20	·35	2·39	46·73	13·40	340·34	0·96
18	18·87	5·34	66·55	·39	2·00	47·13	13·33	191·30	1·00
20	19 01	5·30	164·94	·41	1·59	47·48	13·24	42·30	·03
22	19·13	+5·26	263·35	8·44	1·15	47·77	+13·13	253·33	·06
24	19·22	5·20	1·79	·45	0·69	48·01	12·99	104·39	·08
26	19·29	5·14	100·24	·47	0·21	48·19	12·83	315·47	·10
28	19·34	5·07	198·71	·47	359 73	48·31	12·66	166·57	·10
30	19·36	4·99	297·18	·47	359·23	48·36	12·46	17·67	·11
Feb. 1	19·35	+4·90	35·65	·46	358·73	48·34	+12·25	228·78	·10
3	19·32	4·81	134·11	·45	358·23	48·26	12·02	79·88	·10
5	19·26	4·72	232·56	·43	357·74	48·11	11·79	290·98	·08
7	19·18	4·62	330·99	·40	357·25	47·90	11·55	141·06	·06
9	19·07	4·52	69·39	·37	356·77	47·63	11·30	353·12	·04

Greenw. Noon. 1884.	*Phobos.* a_1	b_1	u_1-U	Diff. 2230° +	P	*Deimos.* a_2	b_2	u_2-U	Diff. 570° +
	″	″	°	°	°	″	″	°	°
Feb. 11	18·94	+4·42	167·76	8·34	356·31	47·30	+11·05	204·16	1·00
13	18·78	4·32	266·10	·30	355·86	46·92	10·80	55·16	0·97
15	18·61	4·22	4·40	·26	355·44	46·49	10·56	266·13	·93
17	18·42	4·13	102·66	·21	355·04	46·01	10·32	117·06	·89
19	18·21	4·04	200·87	·17	354·67	45·49	10·09	327·95	·85
21	17·99	+3·95	299·04	8·12	354·32	44·94	+ 9·86	178·80	·80
23	17·76	3·86	37·16	·07	354·00	44·36	9·64	29·60	·76
25	17·51	3·78	135·23	8·01	353·71	43·75	9·44	240·36	·71
27	17·26	3·70	233·24	7·96	353·45	43·12	9·24	91·07	0·65
29	17·00	3·63	331·20	·91	353·23	42·47	9·06	301·72	·60
Mar. 2	16·74	+3·56	69·11	7·85	353·04	41·81	+ 8·90	151·32	·55
4	16 47	3·50	166·96	·80	352·88	41·14	8·74	2·87	·50
6	16·20	3·44	264·76	·75	352·76	40·47	8·60	213·37	·45
8	15·93	3·39	2·51	·70	352·67	39·79	8·47	63·82	·40
10	15·66	3·34	100·21	7·64	352·61	39·12	8·35	274·22	0·36
12	15·39	+3·30	197·85		352·58	38·45	+ 8·25	124·58	

These values are to be interpolated for the times for which the positions of the satellites are required, the equation of time having already been taken into account. The position-angles p and distances s are then to be found by means of the formulæ :—

$$s \sin (p-P) = a \sin (u-U)$$
$$s \cos (p-P) = b \cos (u-U)$$

The satellites move in the direction of *in*creasing position-angles, and will be at their greatest eastern and western elongations (e in pos. P+90° and w in pos. P−90°) about the following hours, Greenwich Mean Time :—

1883.	*Phobos.* h	h	*Deimos.* h	1883.	*Phobos.* h	h	*Deimos.* h
Dec. 19	12·6 *w*	16·5 *e*	15·0 *e*	Dec. 24	11·3 *e*	15·1 *w*	16·2 *e*
20	11·6 *w*	15·4 *e*	21·3 *e*	25	10·2 *e*	14·0 *w*	7·3 *w*
21	10·6 *w*	14·4 *e*	12·4 *w*	26	9·2 *e*	13·0 *w*	13·6 *w*
22	9·5 *w*	13·3 *e*	18·7 *w*	27	12·0 *w*	15·8 *e*	19·9 *w*
23	12·3 *e*	16·1 *w*	9·9 *e*	28	10·9 *w*	14·7 *e*	11·1 *e*

		Phobos.	*Deimos.*			*Phobos.*	*Deimos.*
1883.		h	h	1884.		h	h
Dec.	29	9·9 *w*	13·7 *e*	Feb.	4	9·5 *w*	13·3 *e*
	30	12·7 *e*	16·5 *w*		5	8·4 *w*	12·3 *e*
	31	11·6 *e*	15·5 *w*		6	11·2 *e*	15·1 *w*
1884.					7	10·2 *e*	14·0 *w*
Jan.	1	10·6 *e*	14·4 *w*		8	9·1 *e*	13·0 *w*
	2	9·5 *e*	13·4 *w*		9	8·1 *e*	11·9 *w*
	3	12·3 *w*	16·2 *e*		10	10·9 *w*	14·7 *e*
	4	11·3 *w*	15·1 *e*		11	9·8 *w*	13·7 *e*
	5	10·2 *w*	14·1 *e*		12	8·8 *w*	12·6 *e*
	6	9·2 *w*	13·0 *e*		13	7·7 *w*	11·6 *e*
	7	12·0 *e*	15·8 *w*		14	10·5 *e*	14·3 *w*
	8	10·9 *e*	14·8 *w*		15	9·5 *e*	13·3 *w*
	9	9·9 *e*	13·7 *w*		16	8·4 *e*	12·3 *w*
	10	8·9 *e*	12·7 *w*		17	7·4 *e*	11·2 *w*
	11	11·6 *w*	15·5 *e*		18	10·2 *w*	14·0 *e*
	12	10·6 *w*	14·4 *e*		19	9·1 *w*	12·9 *e*
	13	9·5 *w*	13·4 *e*		20	8·1 *w*	11·9 *e*
	14	8·5 *w*	12·3 *e*		21	7·0 *w*	10·9 *e*
	15	11·3 *e*	15·1 *w*		22	9·8 *e*	13·6 *w*
	16	10·2 *e*	14·1 *w*		23	8·8 *e*	12·6 *w*
	17	9·2 *e*	13·0 *w*		24	7·7 *e*	11·6 *w*
	18	12·0 *w*	15·8 *e*		25	6·7 *e*	10·5 *w*
	19	10·9 *w*	14·8 *e*		26	9·5 *w*	13·3 *e*
	20	9·9 *w*	13·7 *e*		27	8·4 *w*	12·3 *e*
	21	8·8 *w*	12·7 *e*		28	7·4 *w*	11·2 *e*
	22	11·6 *e*	15·4 *w*		29	6·4 *w*	10·2 *e*
	23	10·6 *e*	14·4 *w*	Mar.	1	9·1 *e*	13·0 *w*
	24	9·5 *e*	13·4 *w*		2	8·1 *e*	11·9 *w*
	25	8·5 *e*	12·3 *w*		3	7·1 *e*	10·9 *w*
	26	11·3 *w*	15·1 *e*		4	9·8 *w*	13·7 *e*
	27	10·2 *w*	14·0 *e*		5	8·8 *w*	12·6 *e*
	28	9·2 *w*	13·0 *e*		6	7·8 *w*	11·6 *e*
	29	11·9 *e*	15·8 *w*		7	6·7 *w*	10·6 *e*
	30	10·9 *e*	14·7 *w*		8	9·5 *e*	13·3 *w*
	31	9·9 *e*	13·7 *w*		9	8·5 *e*	12·3 *w*
Feb.	1	8·8 *e*	12·6 *w*		10	7·4 *e*	11·3 *w*
	2	11·6 *w*	15·4 *e*		11	6·4 *e*	10·2 *w*
	3	10·5 *w*	14·4 *e*		12	9·2 *w*	13·0 *e*

In order to determine the longitudes of the satellites in their orbits properly it is essential that observations should be taken when the satellites are as far away from their greatest elongations as they can be seen.

In extending the ephemeris as far as it is given I have been guided by the circumstance that *Deimos* has been observed for position at the Harvard College Observatory on Jan. 10, 1880.

Erratum.

Vol. XLIII., page 285, 1882, Oct. 24, *for* Reapp. 51 Piscium, *read* Disapp. 51 Piscium.